

What is Claimed:

1 1. An electrically-pumped terahertz (THz) frequency radiation
2 source comprising:

3 an optical gain material formed substantially of at least one group IV
4 element and doped with at least one dopant having an intra-center transition
5 frequency in a range of about 0.3THz to 30THz;

6 a first electrode electrically coupled to the optical gain material; and

7 a second electrode electrically coupled to the optical gain material.

1 2. The electrically-pumped THz frequency radiation source of claim
2 1, wherein the optical gain material includes at least one of:

3 a crystalline material formed of one group IV element;

4 a crystalline material formed of an alloy of group IV elements; or

5 an amorphous material formed of a group IV element.

1 3. The electrically-pumped THz frequency radiation source of claim
2 1, wherein the optical gain material is selected from a group consisting of: diamond,
3 crystalline silicon, crystalline germanium, crystalline silicon carbide, crystalline silicon
4 germanium, polycrystalline silicon, amorphous diamond, amorphous silicon, and
5 amorphous germanium.

1 4. The electrically-pumped THz frequency radiation source of claim
2 1, wherein the at least one dopant is one of a group III element or a group V
3 element.

1 5. The electrically-pumped THz frequency radiation source of claim
2 1, wherein the at least one dopant is a shallow depth dopant.

1 6. The electrically-pumped terahertz frequency radiation source of
2 claim 1, wherein the at least one dopant is selected from a group consisting of:
3 boron, phosphorus, gallium, antimony, arsenic, and aluminum.

1 7. The electrically-pumped THz frequency radiation source of claim
2 1, wherein:

3 the at least one dopant includes a first co-dopant of a first carrier type
4 and a second co-dopant of a second carrier type to compensate the first co-dopant;
5 and

6 a first dopant concentration of the first co-dopant is at least five times
7 a second dopant concentration of the second co-dopant.

1 8. The electrically-pumped THz frequency radiation source of claim
2 1, wherein:

3 the at least one dopant includes;

4 a first co-dopant of a first carrier type having a first intra-center
5 transition frequency; and

6 a second co-dopant of the first carrier type having a second
7 intra-center transition frequency;

8 a first dopant concentration of the first co-dopant is approximately
9 equal to a second co-dopant concentration of the second dopant; and

10 the first intra-center transition frequency is not equal to the second
11 intra-center transition frequency.

1 9. The electrically-pumped THz frequency radiation source of claim
2 1, wherein a resistivity of the optical gain material is in the range of about 1 to 10
3 ohm-cm.

1 10. The electrically-pumped THz frequency radiation source of claim
2 1, wherein:

3 the first electrode is formed of at least one of aluminum, gold, silver,
4 copper, nickel, titanium, tungsten, platinum, germanium, polyaniline, or polysilicon;
5 and

6 the second electrode is formed of at least one of aluminum, gold,
7 silver, copper, nickel, titanium, tungsten, platinum, germanium, polyaniline, or
8 polysilicon.

1 11. The electrically-pumped THz frequency radiation source of claim
2 1, wherein the first electrode forms a Schottky barrier contact with the optical gain
3 material.

1 12. The electrically-pumped THz frequency radiation source of claim
2 1, wherein the first electrode forms a substantially ohmic contact with the optical
3 gain material.

1 13. The electrically-pumped THz frequency radiation source of claim
2 1, further comprising:

3 a first reflective element and a second reflective element substantially
4 parallel to the first reflective element, the first reflective element and the second
5 reflective element being arranged on either side of the optical gain material to form a
6 Fabry-Perot laser cavity;

7 wherein;

8 a reflectivity of the first reflective element is less than 100%;
9 and

10 the electrically-pumped THz frequency radiation source emits
11 coherent THz frequency radiation through the first reflective element.

1 14. The electrically-pumped THz frequency radiation source of claim
2 1, wherein the optical gain material is coupled to a substrate.

1 15. The electrically-pumped THz frequency radiation source of claim
2 14, wherein:

3 the substrate includes a distributed feedback element;

4 the distributed feedback element is optically coupled to the optical gain
5 material; and

6 the electrically-pumped THz frequency radiation source emits coherent
7 THz frequency radiation.

1 16. The electrically-pumped THz frequency radiation source of claim
2 1, wherein the optical gain material is formed as a doped region within a
3 substantially undoped material formed substantially of at least one group IV element.

1 17. A method of manufacturing a terahertz (THz) frequency
2 radiation source comprising the steps of:

3 a) providing an optical gain material formed substantially of at
4 least one group IV element and doped with at least one dopant having an intra-
5 center transition frequency in a range of about 0.3THz to 30THz;

6 b) forming a first electrode electrically coupled to the optical gain
7 material; and

8 c) forming a second electrode electrically coupled to the optical
9 gain material.

1 18. The method of claim 17, wherein step (a) includes the step of:

2 a1) providing a wafer formed substantially of the at least one group
3 IV element and doped with the at least one dopant;

4 a2) dicing the wafer to form a plurality of diced wafer pieces; and

5 a3) selecting one piece of the plurality of diced wafer pieces as the
6 optical gain material.

1 19. The method of claim 17, wherein step (b) includes depositing a
2 metal on a first surface portion of the optical gain material to form a Schottky barrier
3 contact.

1 20. The method of claim 17, wherein step (b) includes:

2 b1) increasing a dopant concentration of a first surface portion of
3 the optical gain material; and

4 b2) depositing a conductive material on the first surface portion of
5 the optical gain material to form a substantially ohmic contact.

1 21. The method of claim 17, wherein:

2 forming the first electrode in step (b) includes at least one of;

3 sputtering conductive material onto a first surface portion of the
4 optical gain material;

5 depositing conductive material onto the first surface portion of
6 the optical gain material by vaporization deposition; or

7 depositing conductive material onto the first surface portion of
8 the optical gain material by evaporation deposition; and

9 forming the second electrode in step (c) includes at least one of;

10 sputtering conductive material onto a second surface portion of
11 the optical gain material;

12 depositing conductive material onto the second surface portion
13 of the optical gain material by vaporization deposition; or

14 depositing conductive material onto the second surface portion
15 of the optical gain material by evaporation deposition.

1 22. A method of manufacturing a terahertz (THz) frequency
2 radiation source comprising the steps of:

3 a) providing a substrate;

4 b) depositing a optical gain material layer on the substrate, the
5 optical gain material layer formed substantially of at least one group IV element and
6 doped with at least one dopant having an intra-center transition frequency in a range
7 of about 0.3THz to 30THz;

8 c) forming a first electrode electrically coupled to the optical gain
9 material layer; and

10 d) forming a second electrode electrically coupled to the optical
11 gain material layer.

1 23. The method of claim 22, wherein depositing the optical gain
2 material layer in step (b) includes at least one of:

3 sputtering optical gain material onto the substrate;

4 depositing the optical gain material onto the substrate by vaporization
5 deposition;

6 depositing the optical gain material onto the substrate by evaporation
7 deposition; or

8 epitaxially growing the optical gain material on the substrate.

1 24. A method of manufacturing a terahertz (THz) frequency
2 radiation source comprising the steps of:

3 a) providing a substantially undoped material formed substantially
4 of at least one group IV element;

5 b) doping at least a portion of the substantially undoped material
6 with at least one dopant having an intra-center transition frequency in a range of
7 about 0.3THz to 30THz to form an optical gain material region;

8 c) forming a first electrode electrically coupled to the optical gain
9 material region; and

10 d) forming a second electrode electrically coupled to the optical
11 gain material region.

1 25. The method of claim 24, wherein doping the portion of the
2 substantially undoped material in step (b) includes at least one of:

3 diffusing the at least one dopant into the portion of the substantially
4 undoped material;

5 ion implanting the at least one dopant into the portion of the
6 substantially undoped material.

1 26. An electrically-pumped terahertz (THz) frequency radiation
2 detector comprising:

3 an optical absorption material formed substantially of at least one
4 group IV element and doped with at least one dopant having an intra-center
5 transition frequency in a range of about 0.3THz to 30THz;

6 a first electrode electrically coupled to the optical absorption material;
7 and

8 a second electrode electrically coupled to the optical absorption
9 material.

1 27. A method of manufacturing a terahertz (THz) frequency
2 radiation detector comprising the steps of:

3 a) providing an optical absorption material formed substantially of
4 at least one group IV element and doped with at least one dopant having an intra-
5 center transition frequency in a range of about 0.3THz to 30THz;

6 b) forming a first electrode electrically coupled to the optical
7 absorption material; and

8 c) forming a second electrode electrically coupled to the optical
9 absorption material.

1 28. A method of manufacturing a terahertz (THz) frequency
2 radiation detector comprising the steps of:

3 a) providing a substrate;

4 b) depositing an optical absorption material layer on the substrate,
5 the optical absorption material layer formed substantially of at least one group IV
6 element and doped with at least one dopant having an intra-center transition
7 frequency in a range of about 0.3THz to 30THz;

8 c) forming a first electrode electrically coupled to the optical
9 absorption material layer; and

10 d) forming a second electrode electrically coupled to the optical
11 absorption material layer.

1 29. A method of manufacturing a terahertz (THz) frequency
2 radiation detector comprising the steps of:

3 a) providing a substantially undoped material formed substantially
4 of at least one group IV element;

5 b) doping at least a portion of the substantially undoped material
6 with at least one dopant having an intra-center transition frequency in a range of
7 about 0.3THz to 30THz to form an optical absorption material region;

8 c) forming a first electrode electrically coupled to the optical
9 absorption material region; and

10 d) forming a second electrode electrically coupled to the optical
11 absorption material region.